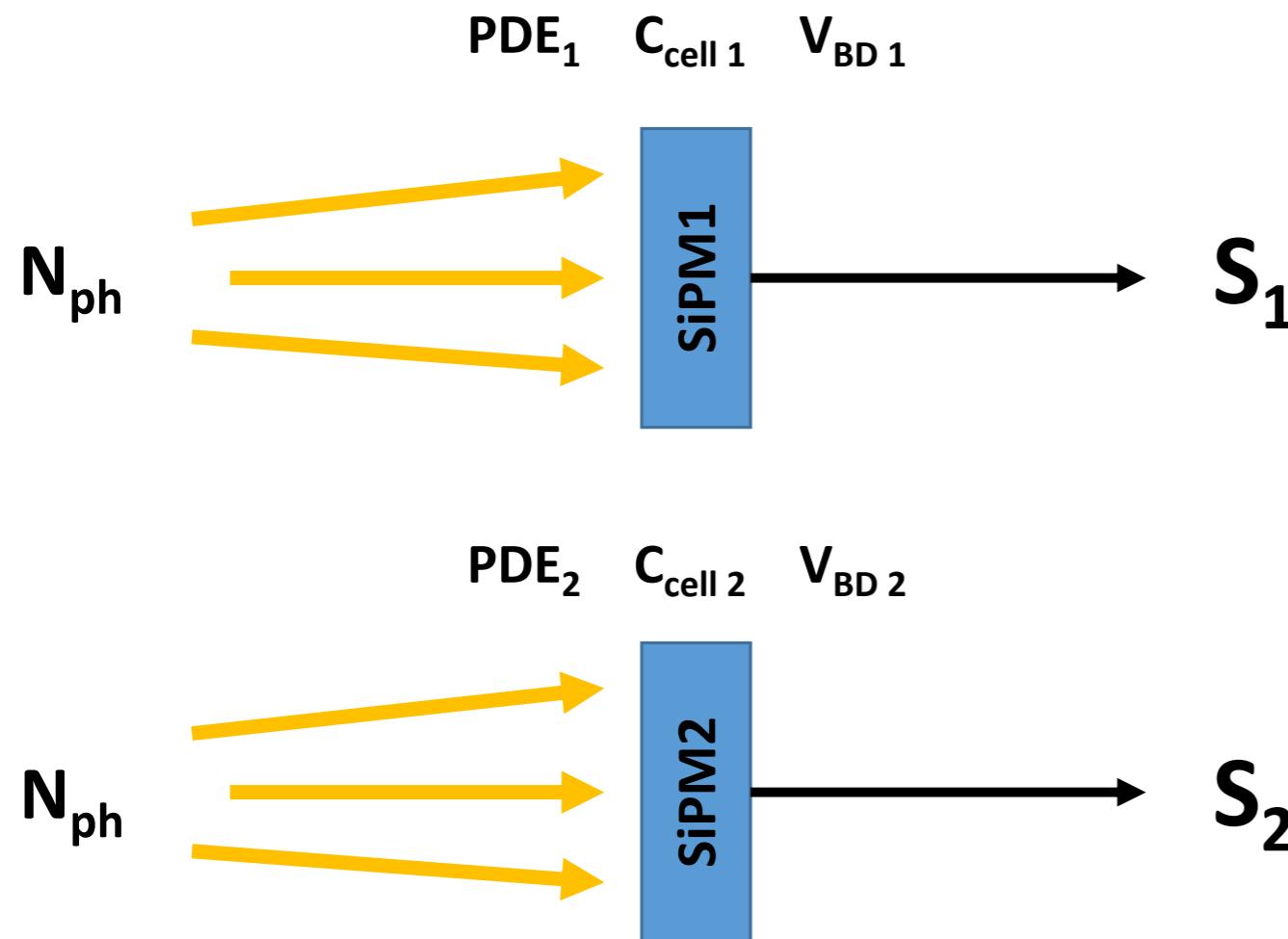


# SiPM selection for sPHENIX

Debrecen, Hungary

# The aim



*The aim is to get the same electric signal for the same photon number.*

$$PDE_1 = PDE_2$$

$$C_{cell\ 1} = C_{cell\ 2}$$

$$V_{BD\ 1} = V_{BD\ 2}$$

$$\downarrow$$
$$S_1 = S_2$$

***Selection by  $PDE$ ,  $C_{cell}$  and  $V_{BD}$  is needed.***

# 2 methods

## Single Photon Spectrum (SPS)

- *complicated (signal)*
- *slow (10 min/SiPM)*
- *single measurement*
- $\text{PDE}, \text{C}_{\text{cell}}, \text{V}_{\text{BD}}$

## I-V curve (IV)

- *simple (DC)*
- *fast (1 min/SiPM)*
- *batch measurement (64 pcs)*
- $\text{PDE}\cdot\text{C}_{\text{cell}}, \text{V}_{\text{BD}}$

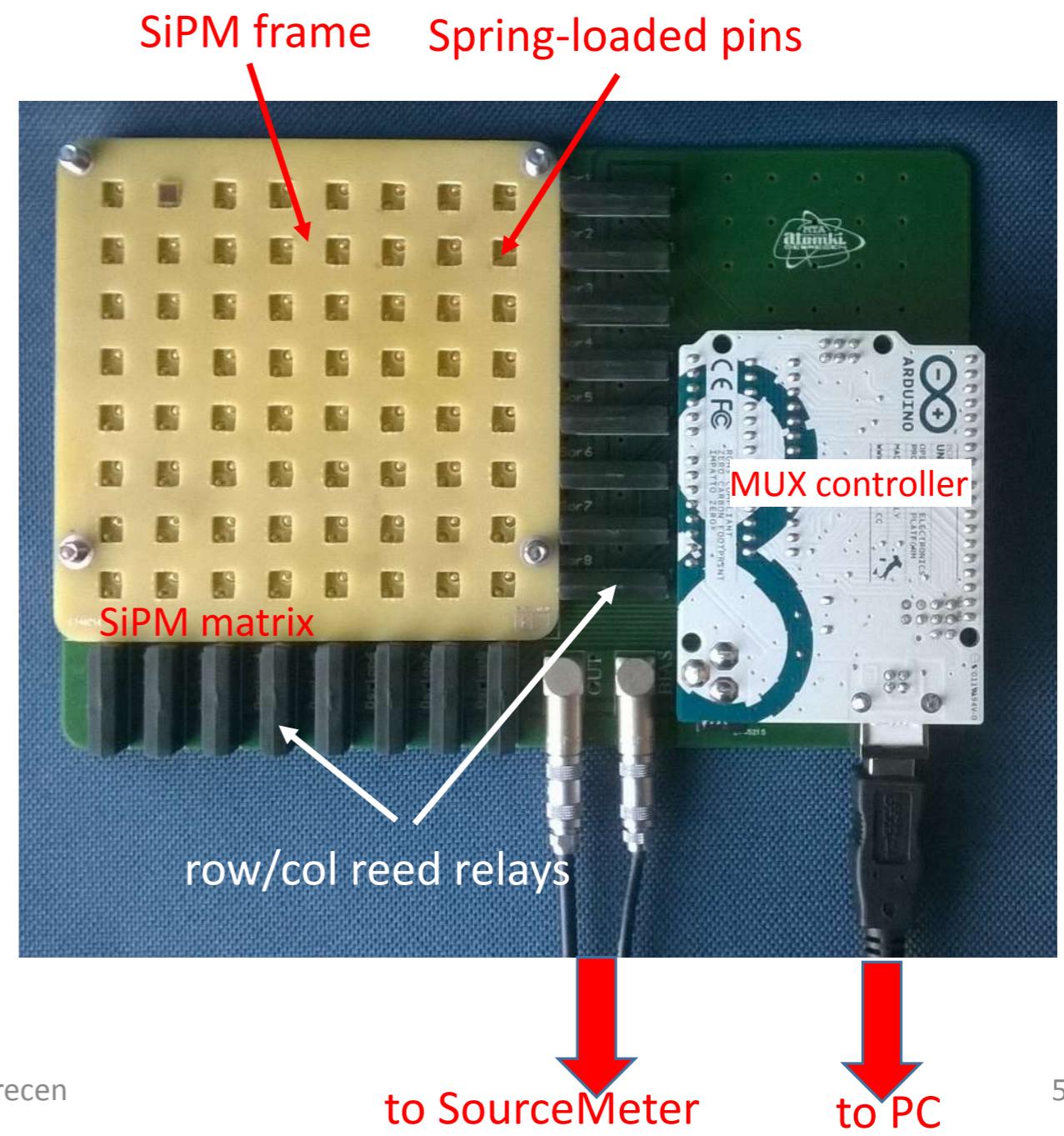
**Is the SPS substitutable with the IV?**

# Measurements

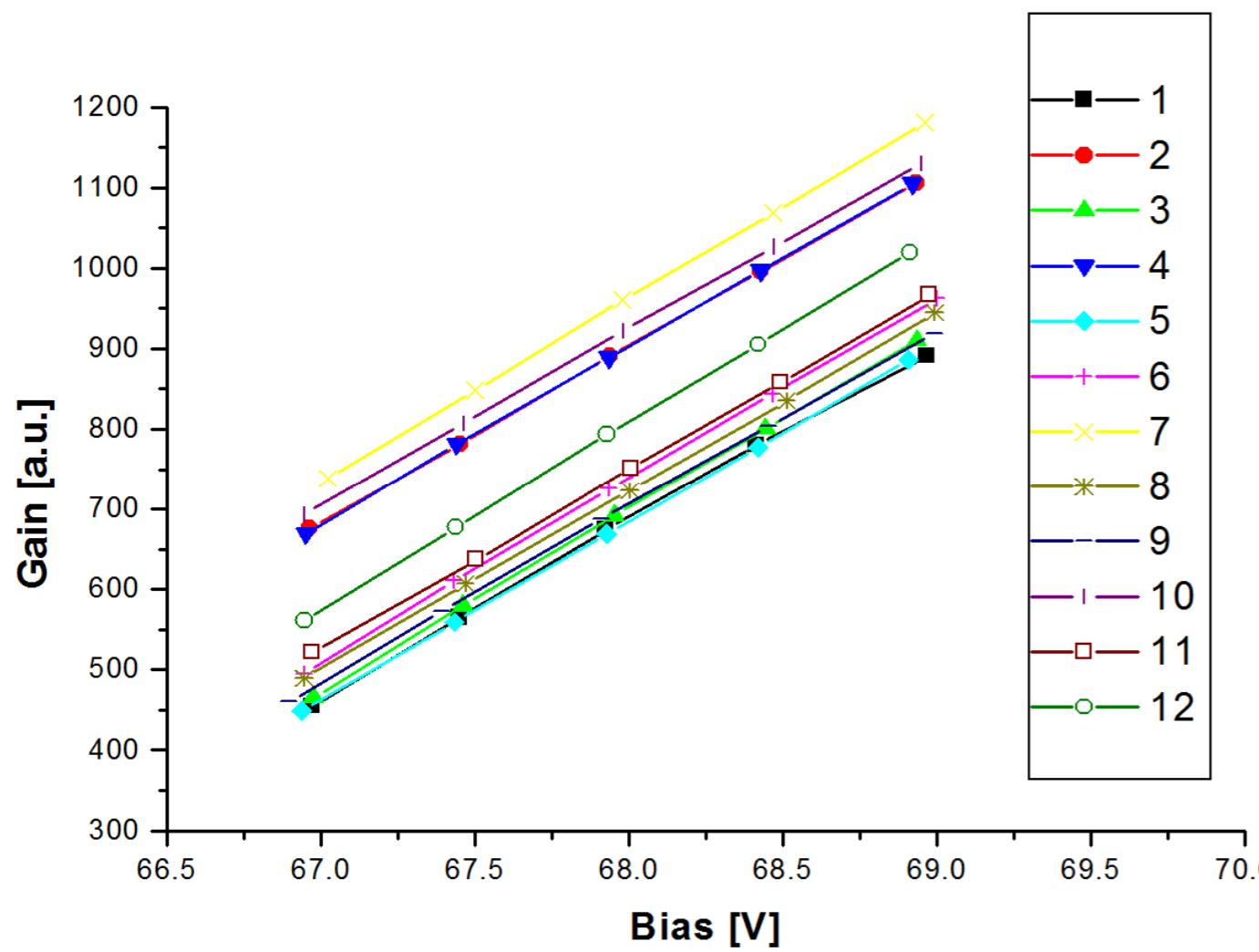
- 12 pcs SiPMs from BNL
- Measured at 6°C
- SPS: gain curves at 5 voltage values
- IV: scanned over 64-68 V

# 8 by 8 multiplexed SiPM matrix frame

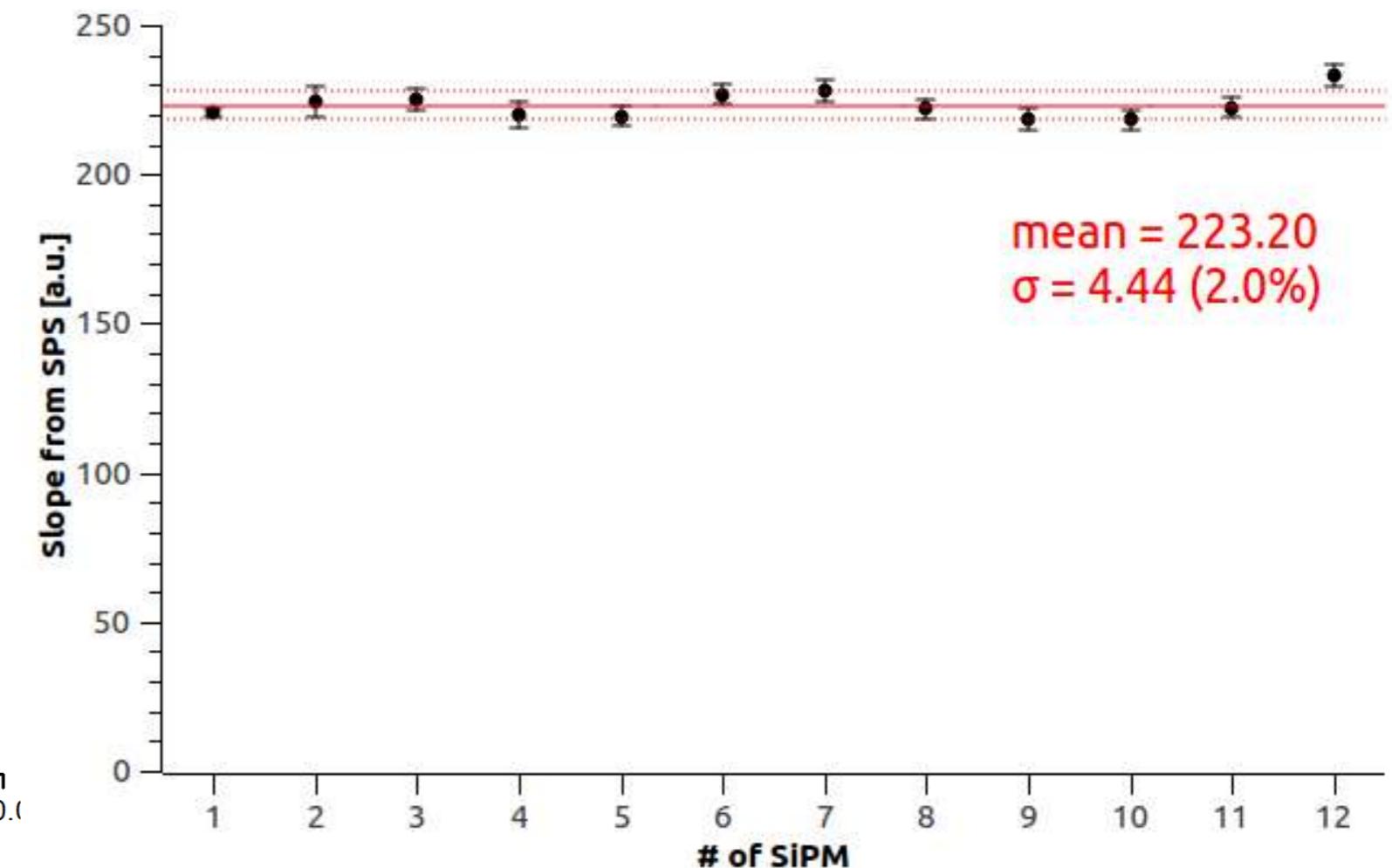
- for DC characterization
- I-V curve with Keithley SourceMeter
- program for DAQ and Analysis



# SPS results



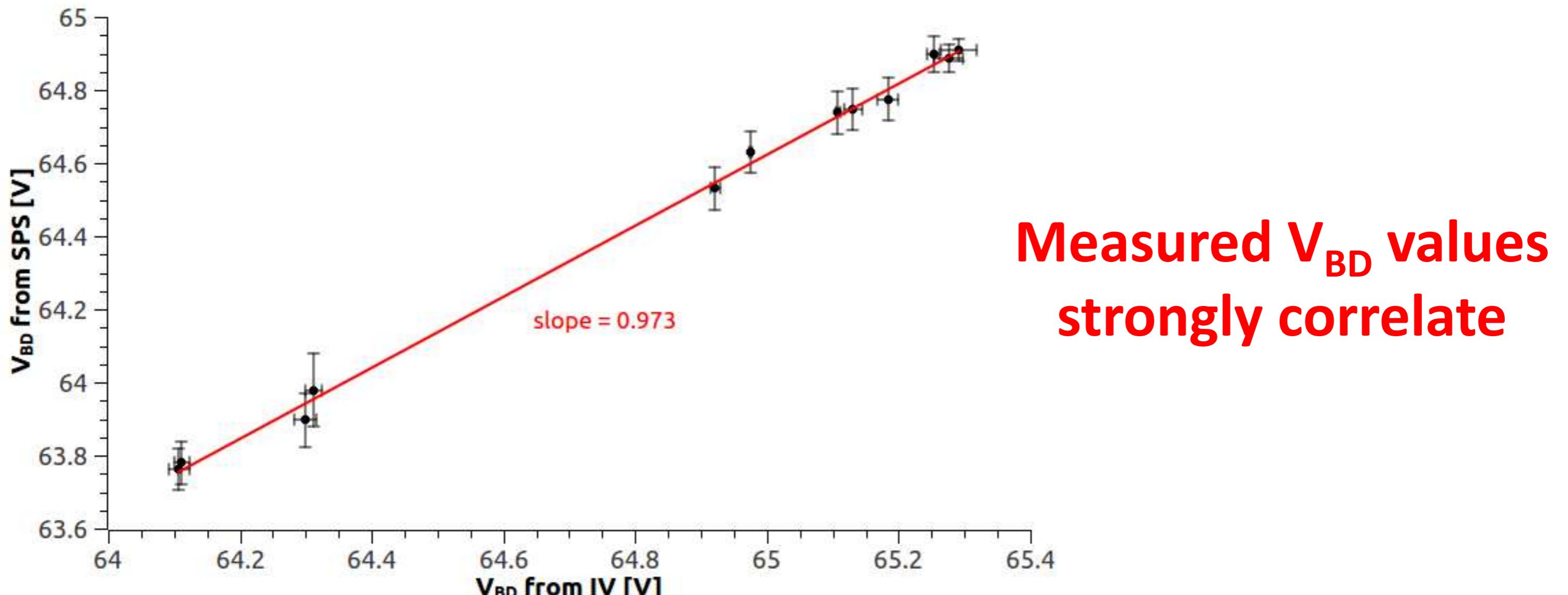
$V_{BD}$  varies



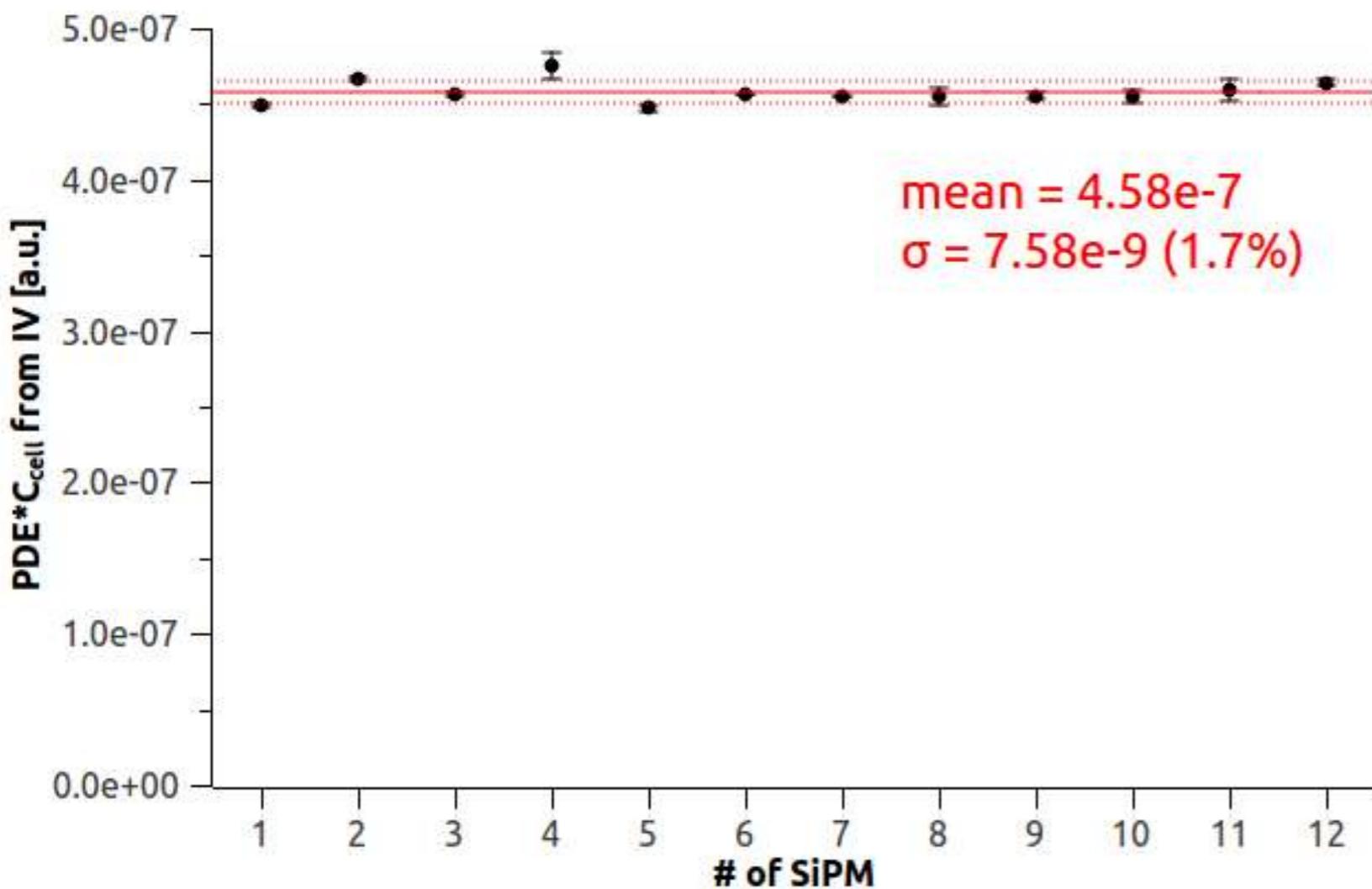
$C_{cell}$  “does not vary”

Therefore we should focus on  $V_{BD}$

# SPS vs IV for $V_{BD}$

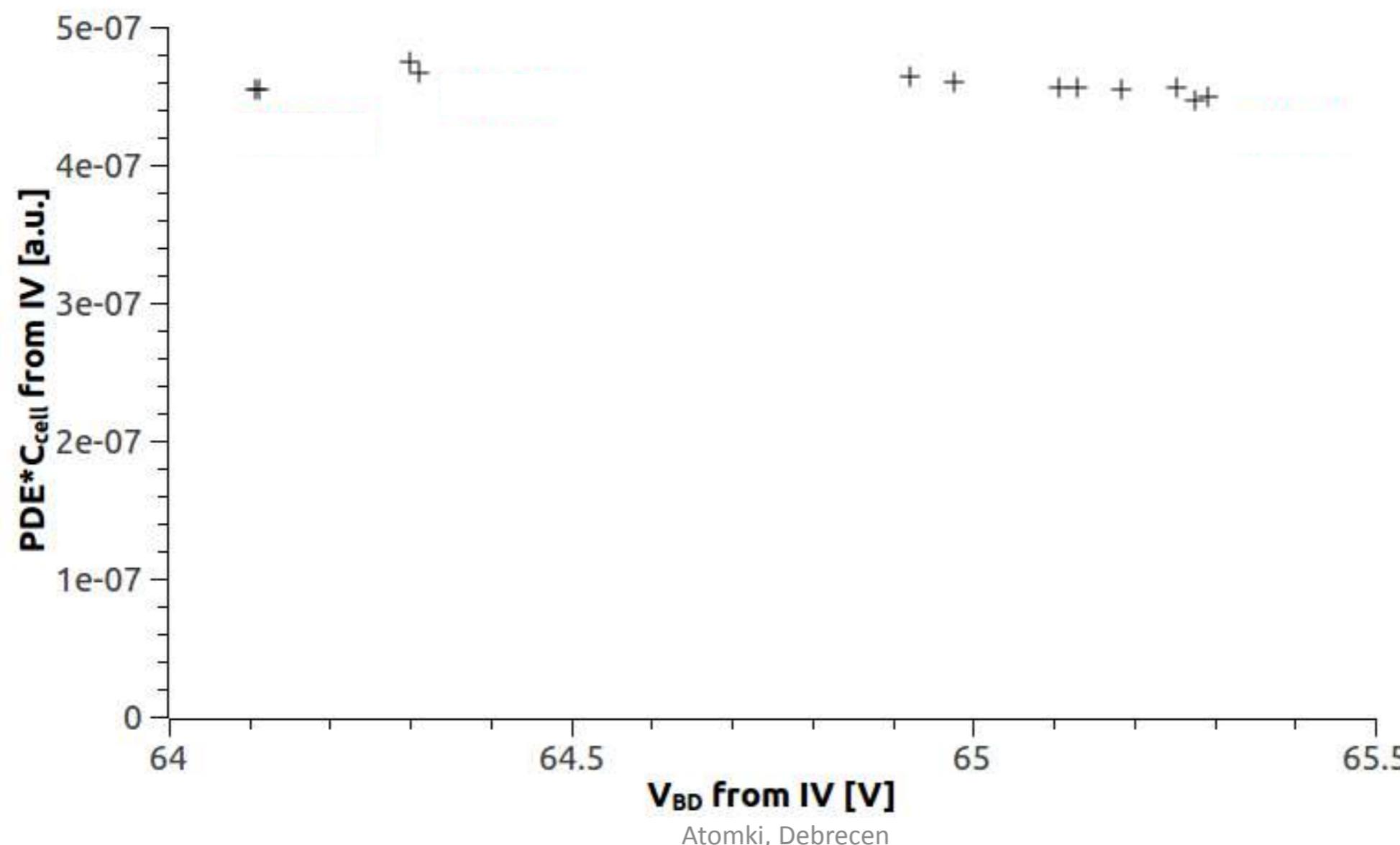


# PDE·C<sub>cell</sub> from IV



**PDE\*C<sub>cell</sub> values are almost the same for all the SiPMs**

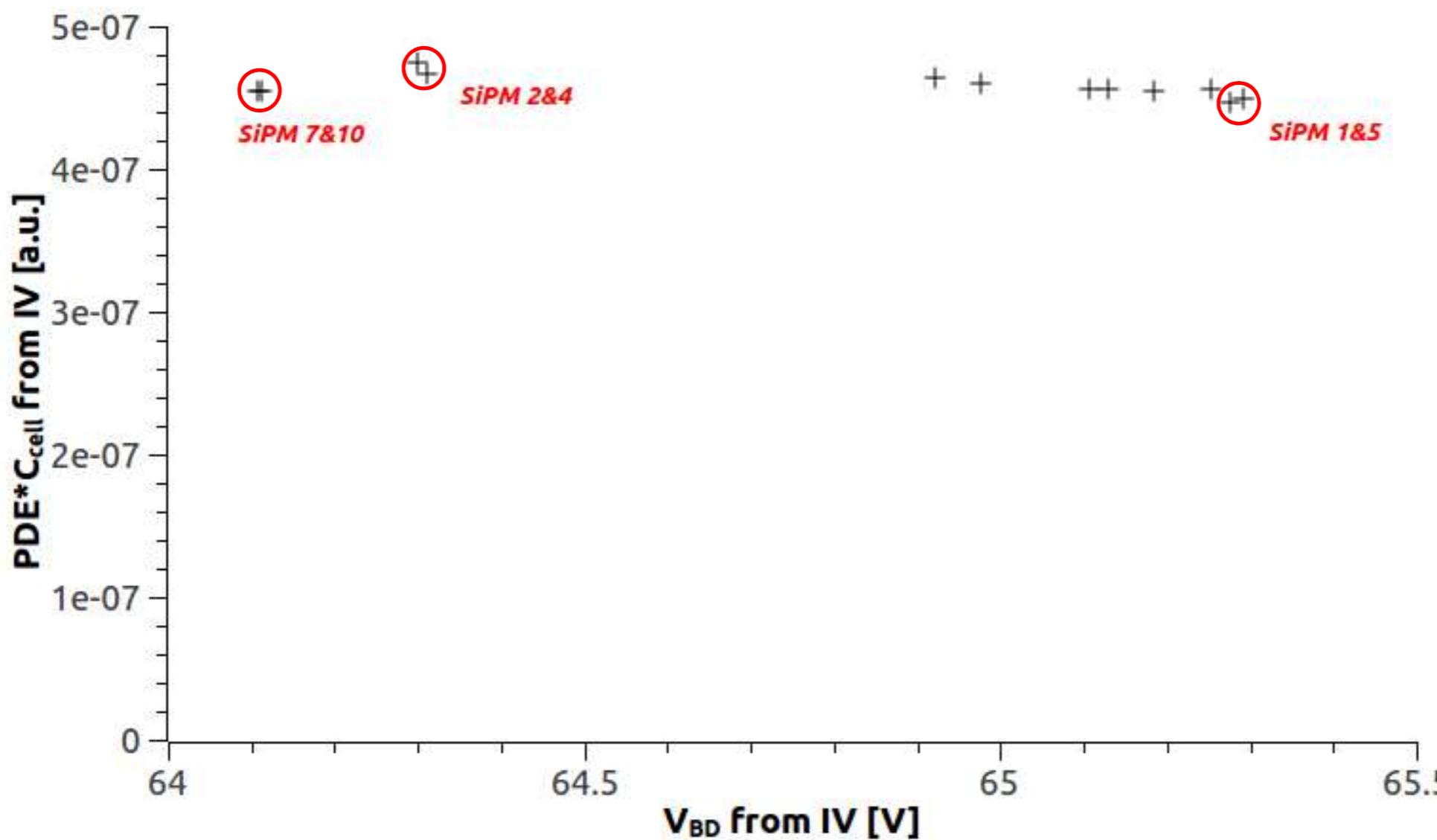
# Selection by PDE·C<sub>cell</sub> and V<sub>BD</sub>



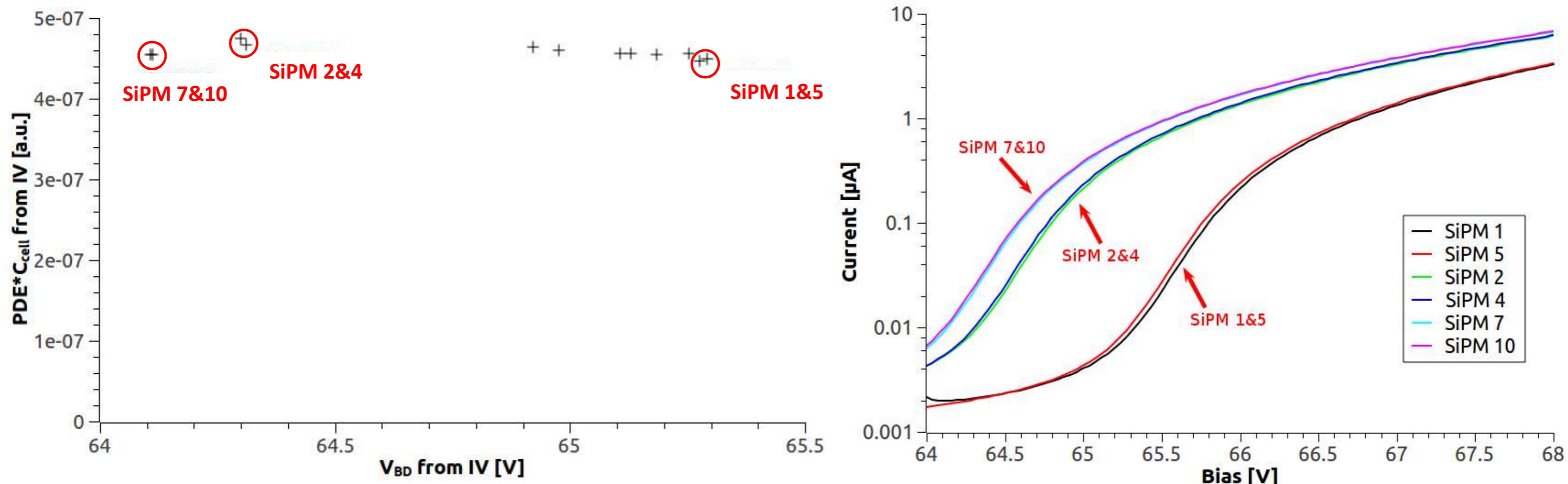
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9

# Selection by PDE·C<sub>cell</sub> and V<sub>BD</sub>



# Selection by PDE·C<sub>cell</sub> and V<sub>BD</sub>



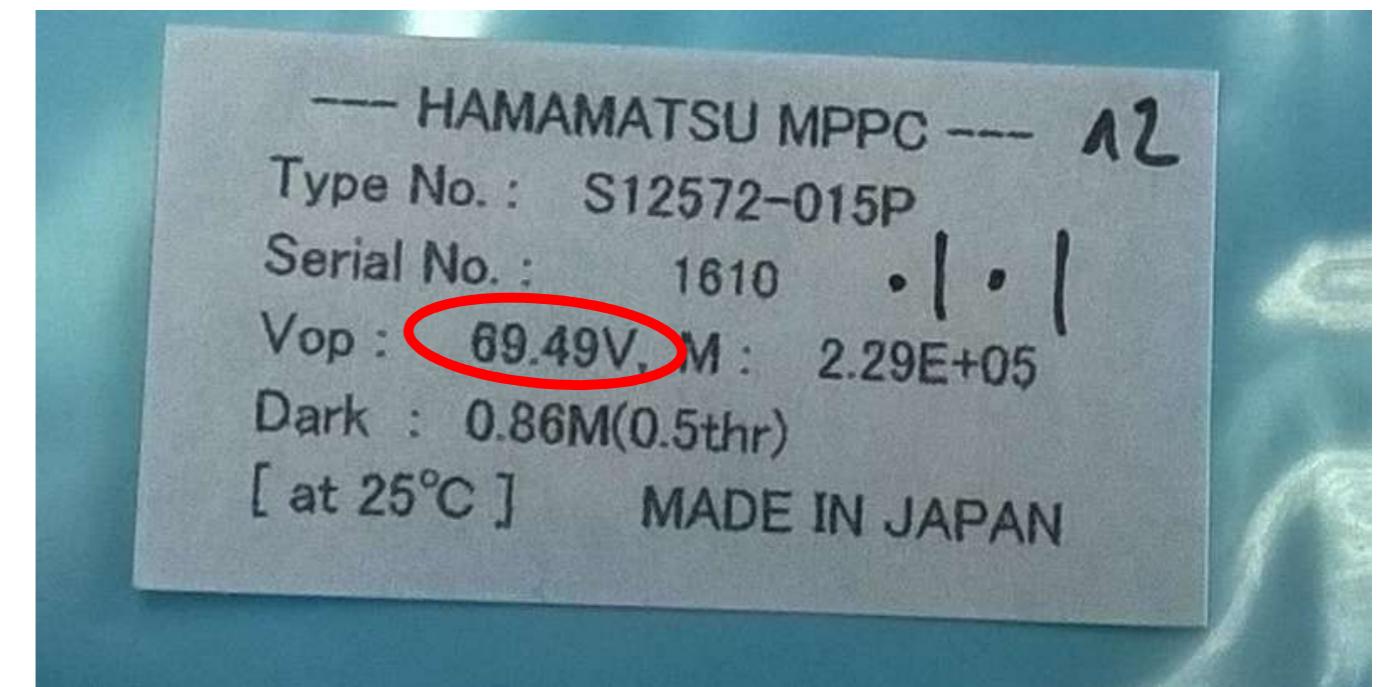
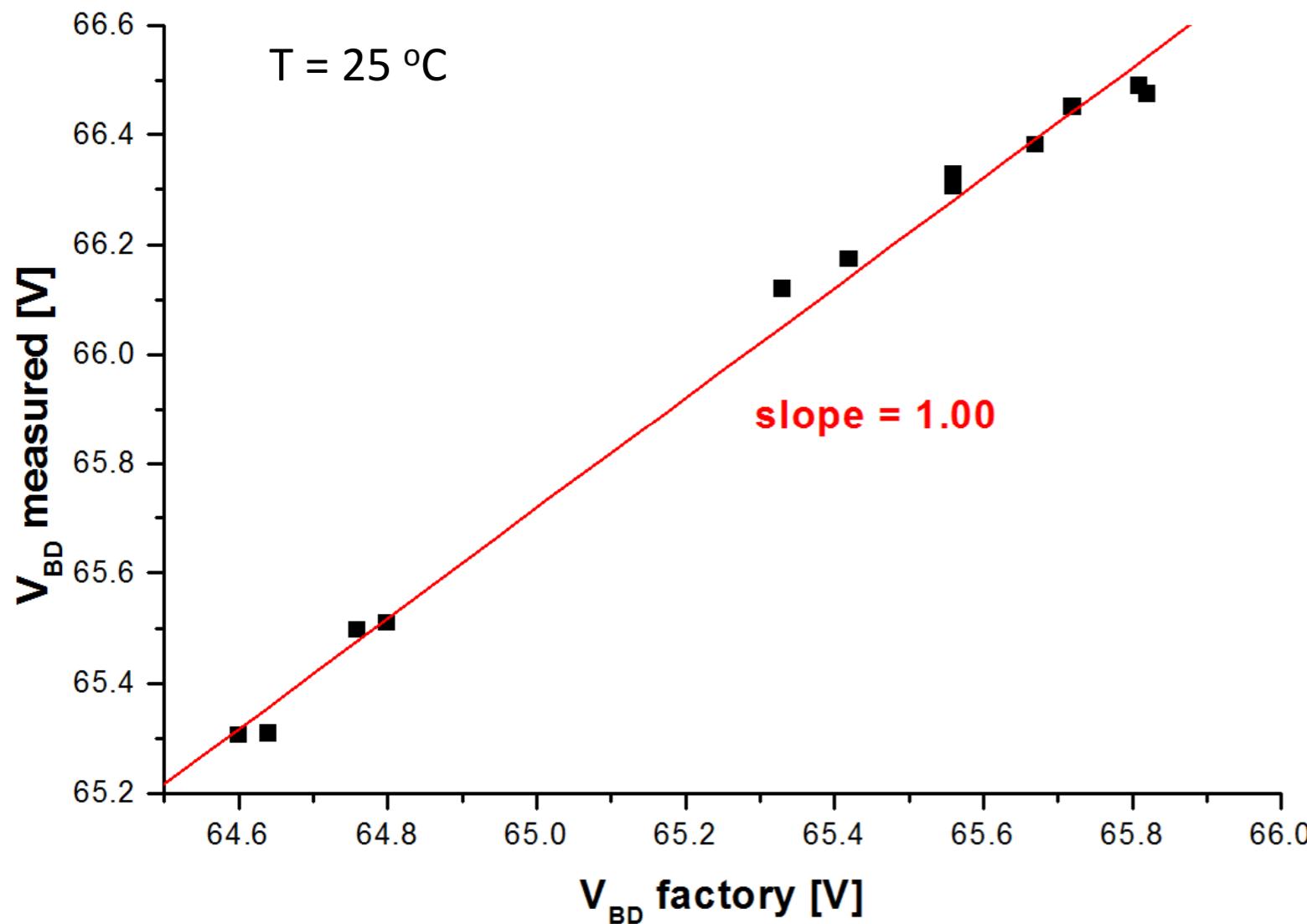
Good correspondence

# Conclusion 1

**Is the SPS substitutable with the IV?**

**YES!**

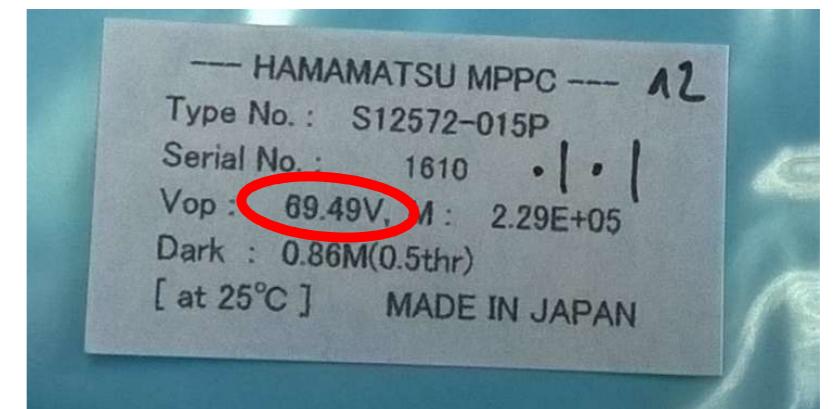
# BUT...



$V_{BD}$  given by Hamamatsu  
correlates so well with  
measured value ...



... no need at all to  
measure further SiPMs  
for the selection?



# Conclusion 2

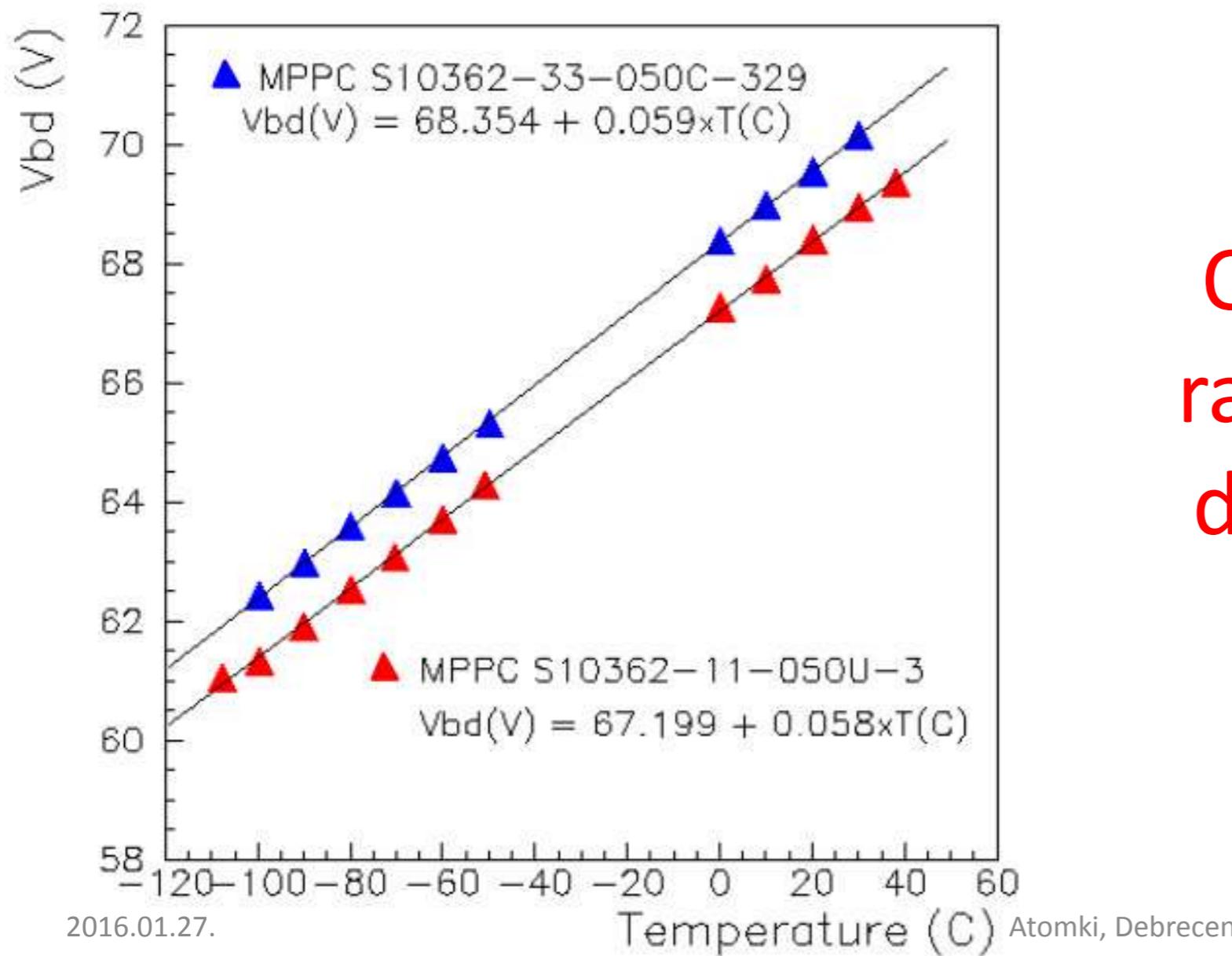
**Worth checking the correspondence between  
Hamamatsu and our  $V_{BD}$  values for a larger  
number of SiPMs**

# APPENDIX

Our measurements were done on slightly varying temperatures around 6°C.

Thus the measured  $V_{BD}$ 's were corrected for 6°C based on the following work:

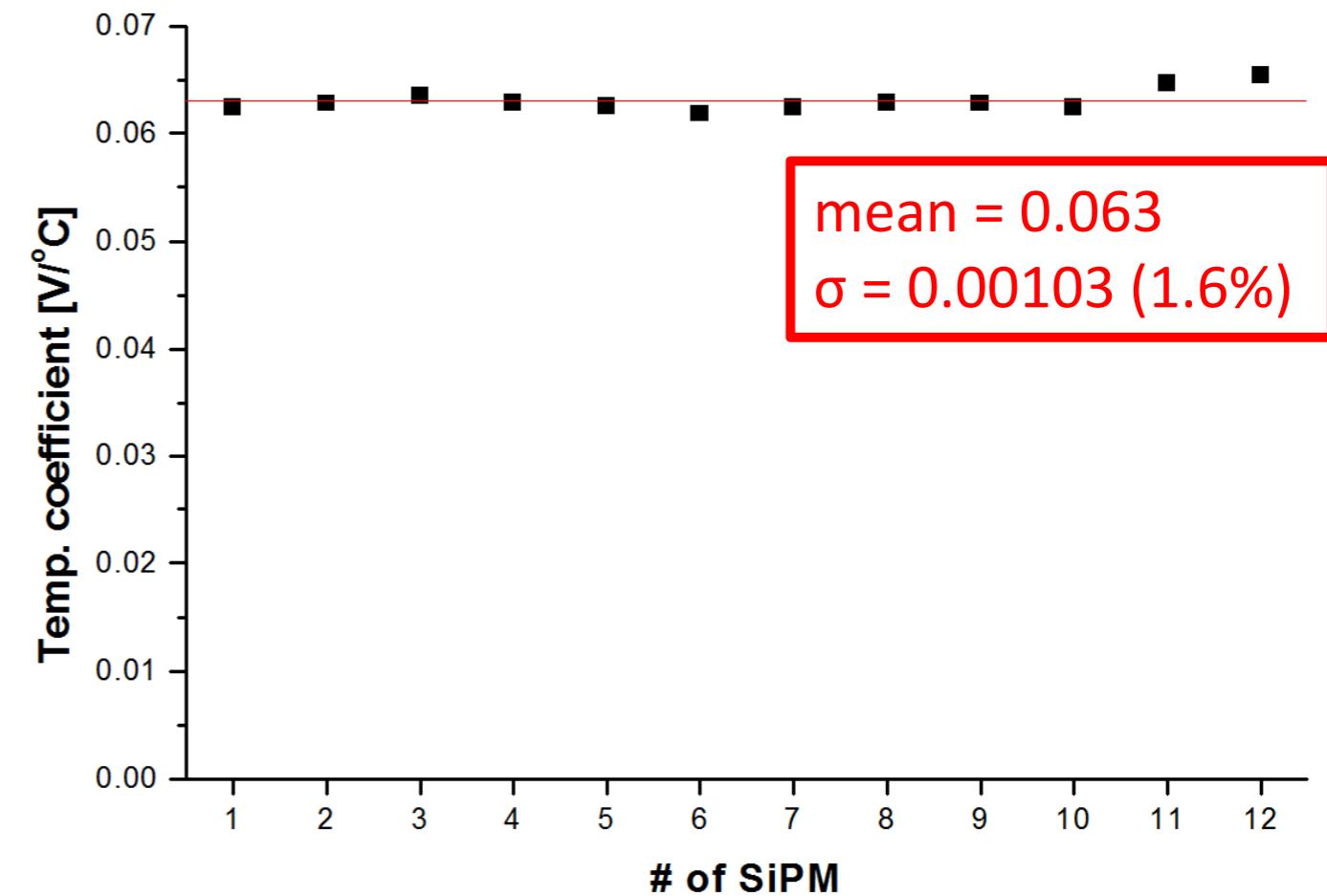
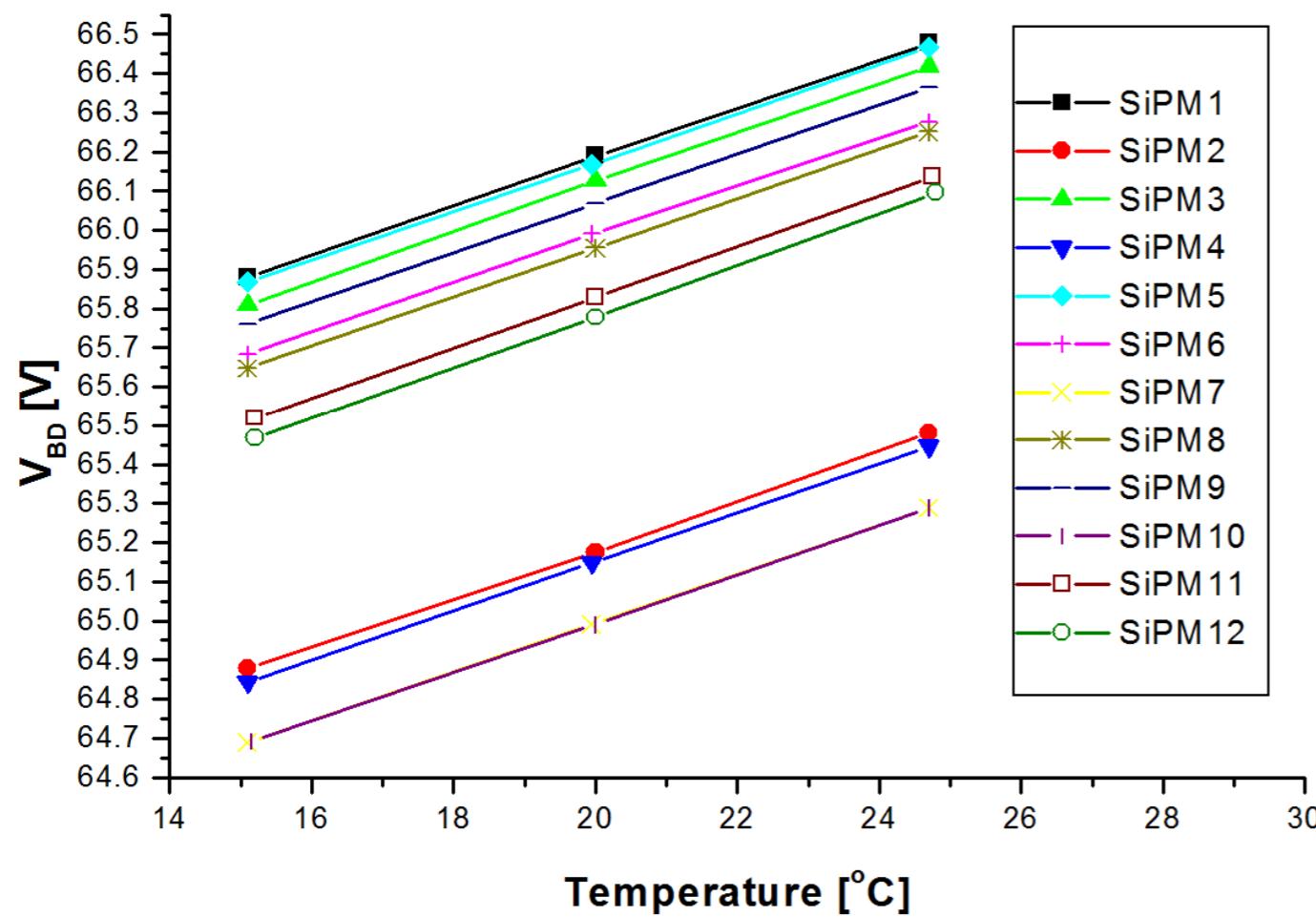
# Temperature and Bias Voltage Dependence of the MPPC Detectors - N. Dinu et al. (2010)



Over a wide temperature range the  $V_{BD}$  temperature dependence is  $\sim 0.06$  V/ $^{\circ}\text{C}$

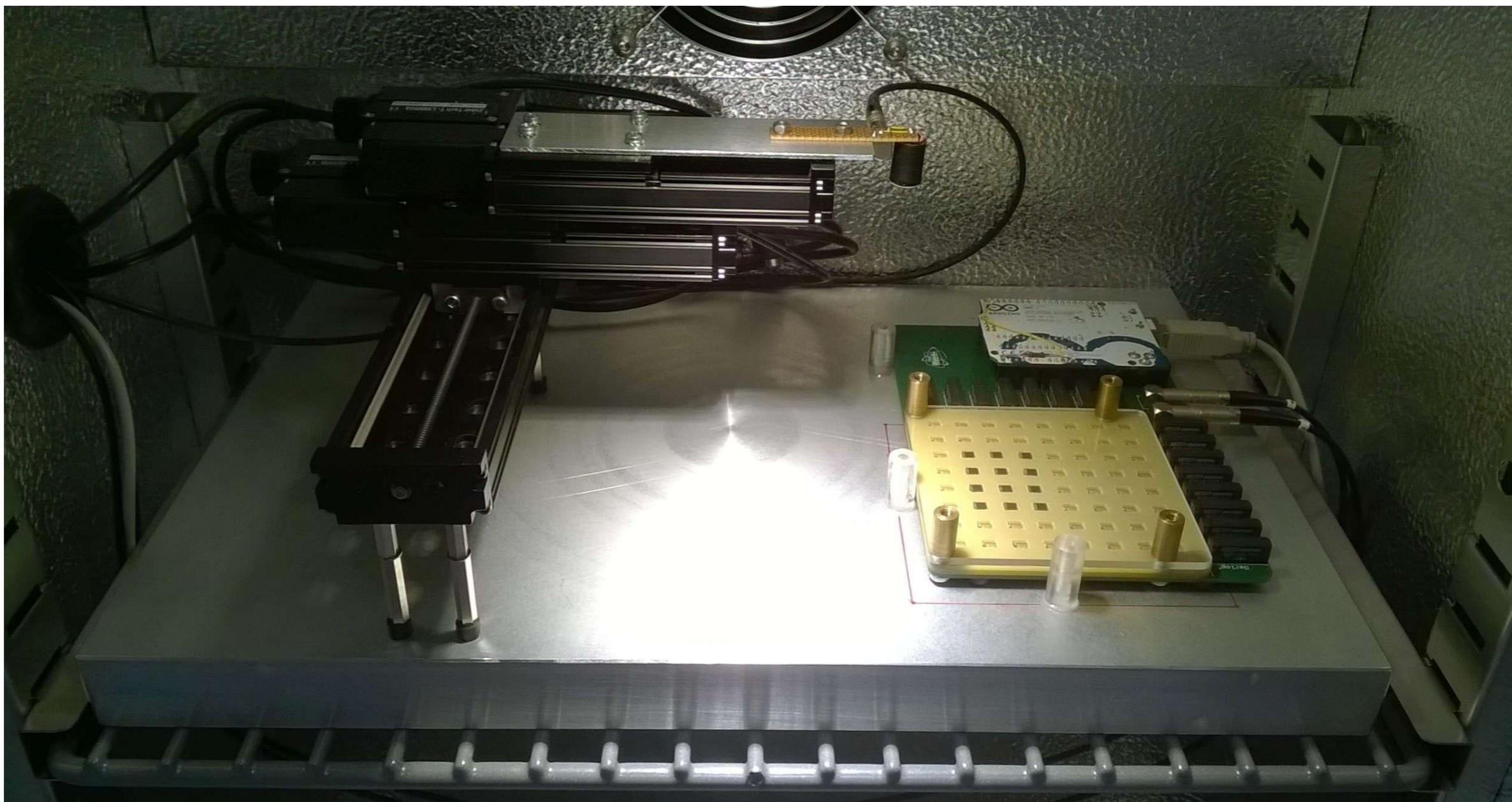
We also checked the temperature dependency for S12572-015P MPPC in our new thermostatic chamber

# Temperature coefficients measured for 12 pcs S12572-015P MPPC



# BACKUP SLIDES

# Setup for IV measurement

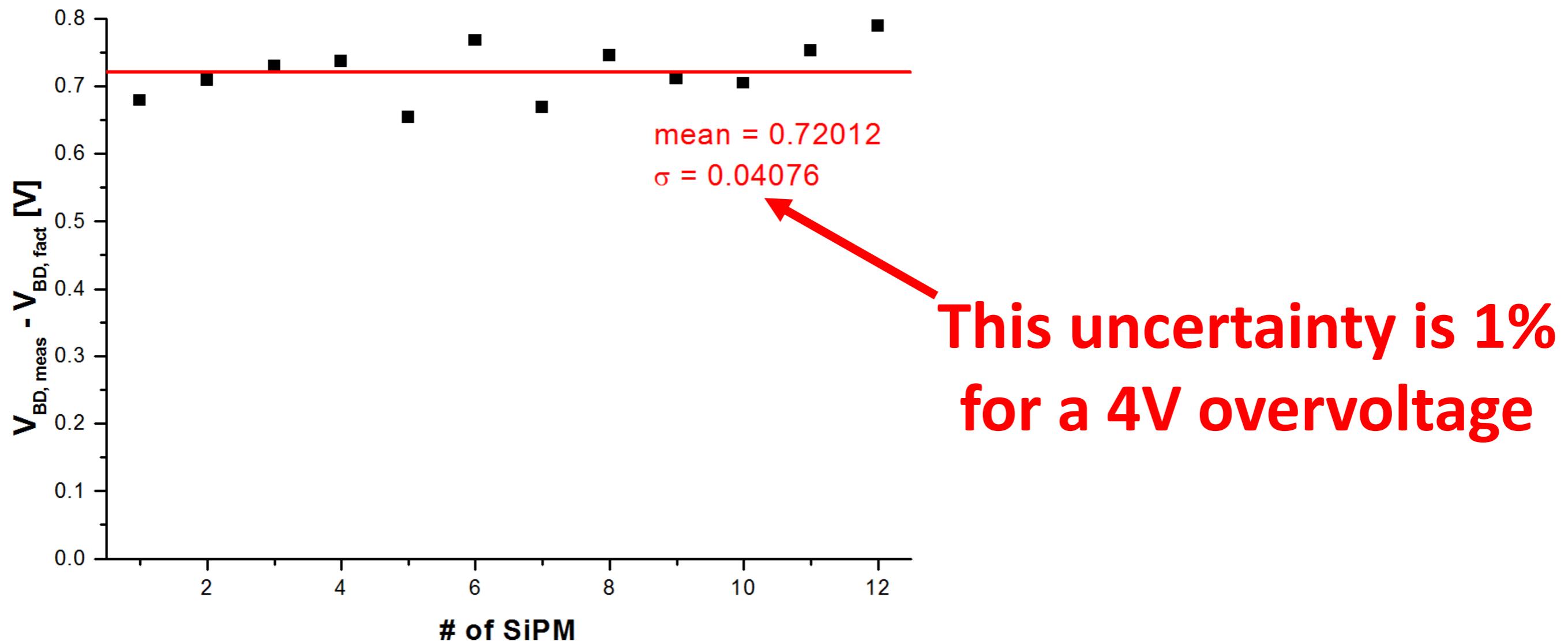


2016.01.27.

Atomki, Debrecen

21

# Difference between measured and factory given $V_{BD}$



# 3<sup>rd</sup> derivative method

# I-V curve model

1. Current of single cell:

$$I_{cell} = [a \cdot V^2 \cdot u(V)] * \delta(V - V_{BD\ cell}) \quad \text{convolution}$$

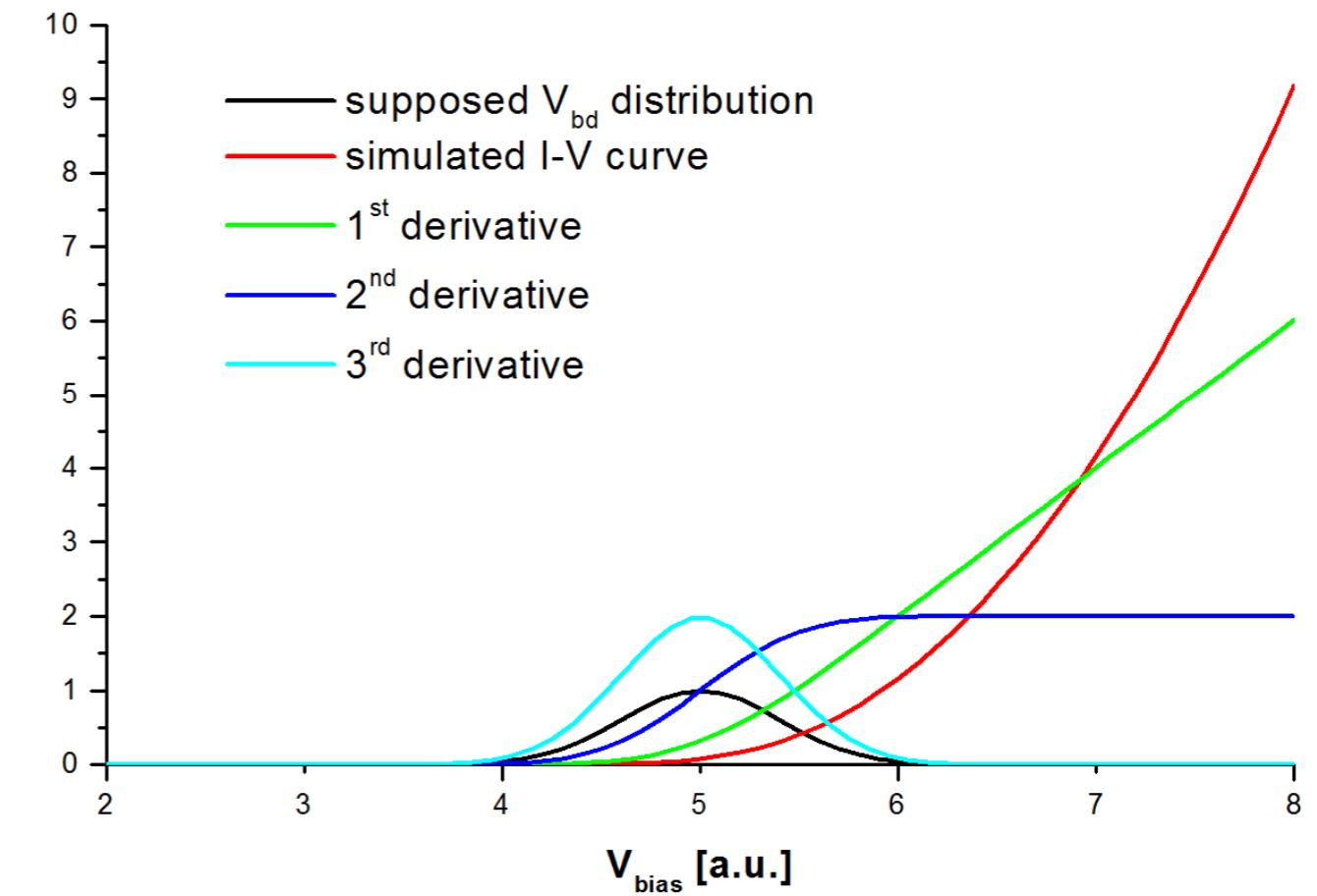
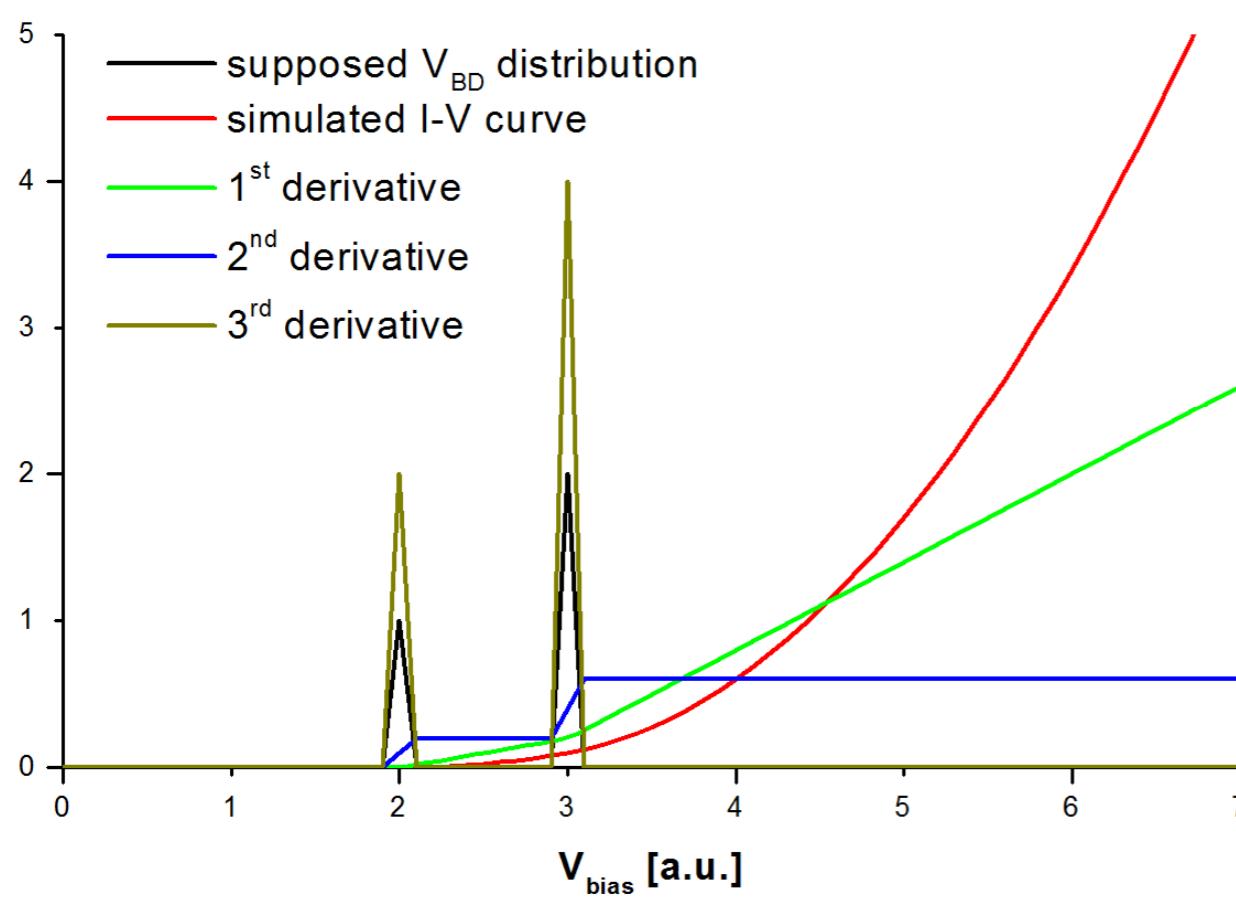
where  $u(V)$  is the unit step function: 
$$u(x) = \begin{cases} 0 & : x < 0 \\ 1 & : x \geq 0 \end{cases}$$

2.  $V_{BD}(V)$  : distribution of  $V_{BD\ cell}$  values over V

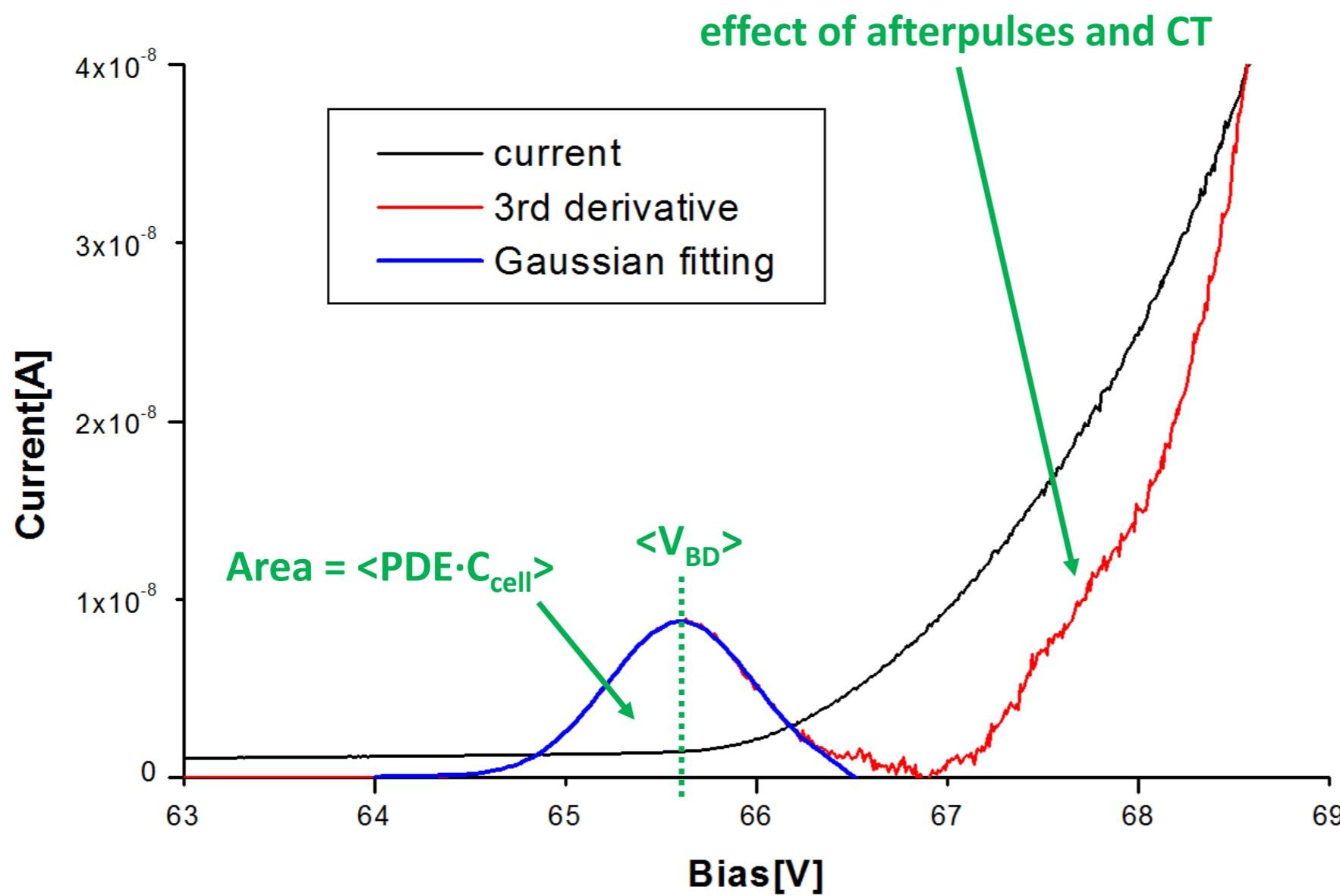
$$I_{SiPM} = [a \cdot V^2 \cdot u(V)] * V_{BD}(V)$$

# 3<sup>rd</sup> derivative

$$I_{SiPM} = [a \cdot V^2 \cdot u(V)] * V_{BD}(V) \quad \longrightarrow \quad (I_{SiPM})''' = 2a \cdot V_{BD}(V)$$



# A real measurement



The mean of  $V_{\text{BD}}$  distribution  
may be considered as the  
 $V_{\text{BD}}$  of the SiPM.